



RF Power Sources
for
Project X Injector Experiment
RFQ
(PXIE)

Ralph J. Pasquinelli

Fermilab

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RF Powers Sources

- *RFQ 162.5 MHz, 150 KW CW includes overhead*
- *RFQ has two drive ports*
- *Two 75 KW CW amplifiers would be suitable*
- *Tev RF “may” be able to supply this power level at 162.5 MHz*
- *Commercial amplifiers: solid-state or tetrode*

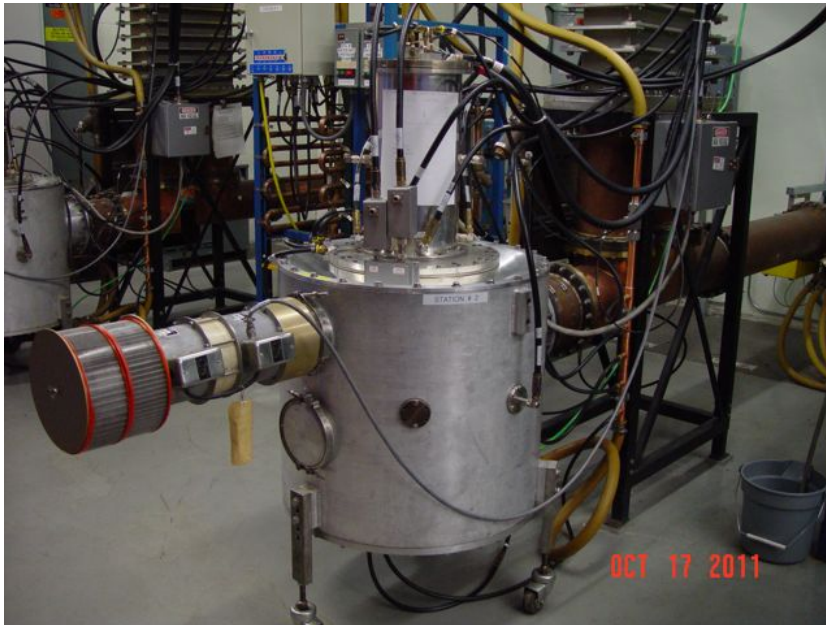


Power Amplifier Requirements

- *50% efficiency at saturated power*
- *40% efficiency at -1 dB power*
- *Water cooled*
- *Bandwidth 2-5 MHz*
- *Sufficient gain for Saturated output with 0 dBm drive*
- *50 ohms input/output impedance*
- *Output protected against opens and shorts*
- *Two drive ports on the RFQ, either two amplifiers or power splitting of one larger amplifier*



Tev RF a Possibility



*8 Operational Systems+Spares
Two Required for NOVA, Balance Available
Tevatron Tetrode Eimac Y567B and New Cavity Design
Two parallel 75 KW CW amplifiers*



Possible “Recyclable” TeV Hardware



TeV High Voltage Modulator



Eimac Y567B Tetrode 150KW Anode Dissipation

ELECTRICAL

Filament: Thoriated-tungsten Mesh

Voltage 15.5 ± 0.75 V

Current @ 15.5 volts 215 A

Direct Interelectrode Capacitances (grounded cathode)

Cin 370 pF

Cout 60 pF

Cgp 1.0 pF

Direct Interelectrode Capacitances (grounded grid)

Cin 175 pF

Cout 60 pF

Cpk 0.35 pF

Frequency of Maximum Rating, CW

108 MHz
250 MHz [PIAC USE]



CPI has been contacted and reports the Y567 B should be able to deliver 75 KW CW @ 162.5 MHz with an anode voltage of 12 KV@ 7.5 amps





RF Sources for PXIE RFQ



From Reid Brandon of CPI

Y-567B in cathode driven configuration as soft class C (closer to class B).

EB = 12kV

EC2 = 1250 V

EC1 = 540 V

IB = 7.5 A DC

iB = 13.8 A

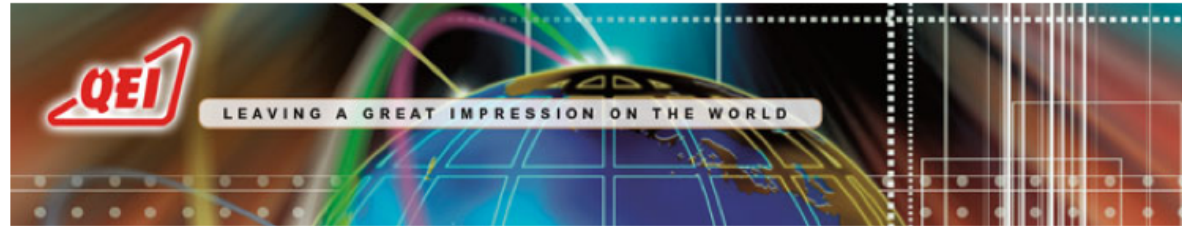
Ic2 = 0.7 A

ic2 = 1.36 A

Plate input power 90.0 kW

Plate output power 77.28 kW before losses
(after 5% losses leaves $P_o = 73.4$ kW)

The grid driven is just up to zero volts from 540 V bias therefore we see no grid current, so it impossible to calculate driving power accurately. In the real world we know it takes power to develop "grid swing" so using the cathode input impedance of 35.6 Ohms, we must have a 540 peak or 381Vrms, and that itself represents 4086W. My calculations (for dc power gain) obtained a drive power = 4212W but in the real world this will be more like 5 to 6 kW (net gain will be around 11.6 dB at 5 kW, using a loss factor of 5% in the cavity). There is some transit time effects beginning at 200 MHz but at 162MHz it should be minimal nonetheless reduce the calculated gain by maybe 0.6 dB = 11 dB overall gain. Plate load $Z = 811$ Ohms, Input $Z = 35.6$ Ohms Feedthru power 3726 W. Screen dissipation is approx 367W (tube rated for 1250W)



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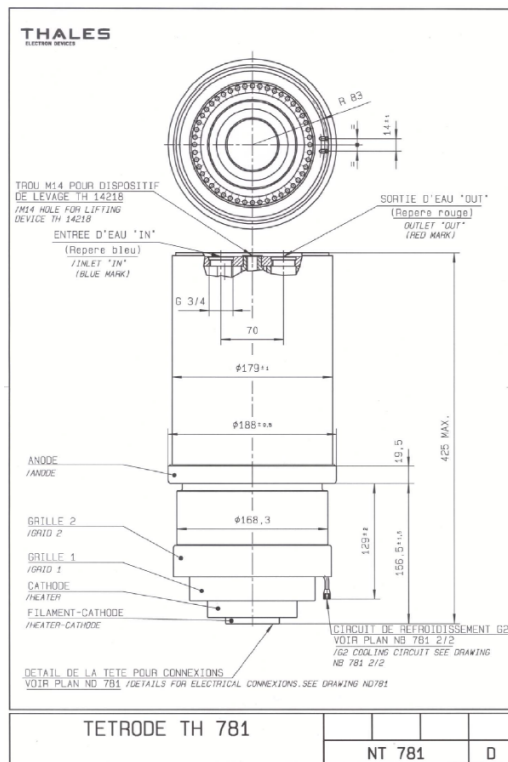
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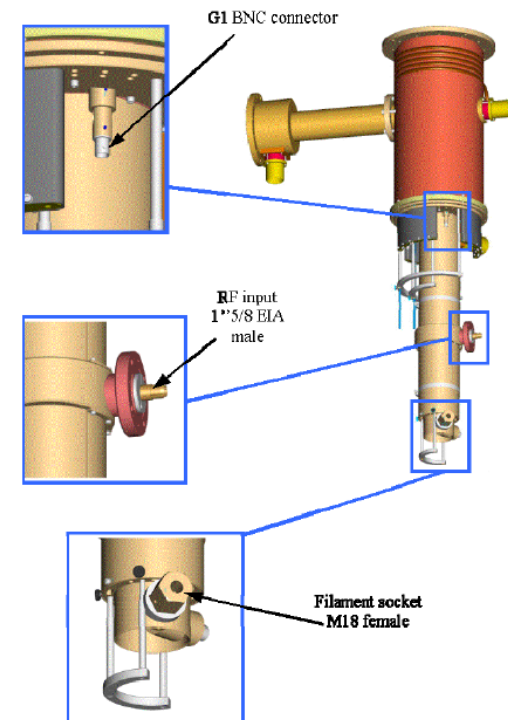


RF Power for 162.5 MHz RFQ



THALES

*Tetrode and In/Out
Cavities
\$191K*



*Thales 781 Tetrode and Cavity
200 Kwatts CW*



200 KW CW RF Power for 162.5 MHz RFQ

Turn Key system estimate \$3 million, 18 months ARO



THOMSON

*Utilizes Thales 781 Tetrode and Cavity
200 Kwatts CW*

Project X

RF Sources for PXIE RFQ



*LBNL dual 60 KW amps...\$1million
Thales TH 571B tetrodes @ 186 MHz*

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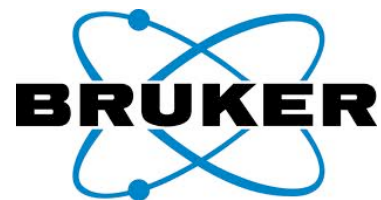
R. J. Pasquinelli

Project X
Project X

RF Sources for PXIE RFQ



ROHDE & SCHWARZ





Issues with RFQ RF Driver

- *Power capabilities of Tevatron tetrode look favorable at 162.5 MHz*
- *Only tube, socket, modulator could be reused from Tev RF hardware*
- *Re-use of Tev hardware requires significant involvement from AD/RF already spread thin*
- *Develop formal spec for multipel vendor bids.*
- *Develop a cost estimate for in house development of a 75 KW amplifier for comparison with commercial equipment*
- *Lead time 18 months to 2 years regardless of approach*